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NONCHEMICAL CONTROL OF PINK BOLLWORMS

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ABSTRACT

The results of an experiment using strip cropping and cultural and introduced parasites for the control of the pink bollworm indicated (1) relatively large populations of naturally occurring predators will build up in alfalfa, sorghum, and cotton, but concentrate in areas in which large supplies of food are available; (2) aphids are the major food source of most populations of naturally occurring predators; (3) predators generally feed upon excesses in the prey population, but only when little food is available do they adequately control a target population; (4) *Bracon kirkpatricki* and *Chelonus blackburni*, even when introduced in relatively large numbers, are inadequate for the control of large, dynamic populations of pink bollworms; (5) strip or block cropping for the promotion of beneficial insects is inadequate as a control for the pink bollworm unless it is accompanied by adequate cultural control; (6) cultural control must be applied systematically over large areas to reduce pink bollworm populations adequately; and (7) migration of pink bollworms into controlled areas remains a constant threat to the effectiveness of the controls.

KEYWORDS: Pink bollworm, *Bracon kirkpatricki*, *Chelonus blackburni*, Inundative parasite releases, Augmentation, Cultural control, Strip cropping

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NONCHEMICAL CONTROL OF PINK BOLLWORMS

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INTRODUCTION

The pink bollworm, *Pectinophora gossypiella* (Saunders), is generally controlled by cultural methods and insecticides. An experiment incorporating many of the best known noninsecticidal controls of the pink bollworm, as well as other cotton pests such as lygus bugs and the bollworm *Heliothis zea* (Boddie), is described in the following discussion.

PHILOSOPHY AND BACKGROUND OF THE EXPERIMENT

Host plants for the various crop pests and their attending predators and parasites have been discussed by Fye (*7*, *11*). A large segment of the insect population in southern Arizona overwinters in London rocket, *Sisymbrium irio* L. As the London rocket matures, the insects move to the desert plants that grow when winter rains are adequate. The foremost host in some desert areas is *Sphaeralcea* spp. (*18*); however, other lush desert plants provide additional major reservoirs. During the winter and early spring, aphids and other soft-bodied insects on these plants are the principal food source for predators.

As the desert growth matures, the predators move to wheat and barley and feed on the greenbug, *Schizaphis graminum* (Rondani). At the same time, the early growth of alfalfa, with the attending population of pea aphid, *Acyrthosiphon pisum* (Harris), provides a food source for many naturally occurring predators. The alfalfa continues to serve as a general reservoir for many of the predators throughout the season. As the small grains mature, the predators move to the earliest grain sorghum that may harbor a large population of Biotype C of the greenbug, and the aphids serve as a major food source for a developing large population of natural predators. As the sorghum matures, the mobile forms of the predators move to the cotton, which is in the early to mid-fruiting stage. Large numbers of predators remain in the cotton until the field is sprayed or comes to a point of maturity that forces the predators to move. By then, the lush growth of pigweed, *Amaranthus* spp., has been triggered by the summer rains and provides a refuge in which many soft-bodied insects are available as prey. At the same time, the late-planted sorghum, with small populations of prey, is available to small segments of the predator population. As the late-planted sorghum matures and the alfalfa freezes out, the growth of London rocket again becomes available to the overwintering populations of pests and predators.

The manipulation of this sequence for the greatest use of the naturally occurring predators and parasites requires that the alfalfa be stripcut or block cut (*17*). This practice provides continuous habitats for the beneficial insects and allows retention of the *Lygus* population in the alfalfa. The *Lygus* prefer to remain in the alternate cut of the alfalfa rather than move to the cotton (*16*). If the entire crop of alfalfa is cut, migrations, such as the one described by Bryan et al. (*1*), will occur, and damage of the cotton by the *Lygus* may result.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 14.

The potential of the sorghum as a nursery for large predator populations has been discussed by DeLoach and Peters (*5*), Fye (*6*), Fye and Carranza (*7*), Robinson et al. (*15*), and Burleigh et al. (*3*). If the early sorghum is to be a major nursery for developing predator populations, it must first sustain a strong population of Biotype C of the greenbug. If temperatures are too high, an extensive greenbug population will not develop (*22*) and attending predator populations will be small. If the aphid population develops, the sorghum variety must be sufficiently tolerant to sustain a large population and, at the same time, have minimal loss of yield (*8*). In addition, the maturity of the sorghum must be timed so that as the sorghum dries out the predators will be available for movement into fruiting cotton.

The development of large populations of predators in the wheat and barley is generally dependent on the presence or absence of a large population of the greenbug in these crops. Under the proper climatic conditions, the greenbug populations are adequate to sustain large populations of predators, which may move directly into the young cotton if the two crops are adjacently grown.

Management of the cotton for minimal pest populations should include practices designed for a rapid early set of fruit, for early maturity of the crop, for an early picking date, and prompt crop residue destruction followed by plowing and tillage for an alternate small grain crop or for continued cotton crop production. Rain or irrigation has been suggested as a requisite for sealing the overwintering pest populations in the soil. These practices will provide a minimal population of overwintering pink bollworms.

Experiments with *Bracon kirkpatricki* (Wilkinson) and *Chelonus blackburni* Cameron to control the pink bollworm have shown that the parasites remove varying numbers of pink bollworms from the population (*1*, *2*). However, the experimentation was disrupted by the application of insecticides, and the full evaluation of the parasites was not possible under these adverse conditions. Therefore, the basic concept of the experiment described below was to bring the pink bollworm to low population levels through cultural methods, to manipulate the naturally occurring populations of predators, and to superimpose *B. kirkpatricki* and *C. blackburni* for final control.

FIELD SITE

The field site was located immediately south of Tucson, Ariz., along the west bank of the Santa Cruz River. The soil is a silt loam, which comprises the flood plain of the river. The experiment was replicated four times in 10-acre blocks. Each replicate consisted of 10 acres of alfalfa, 10 acres of wheat followed by late-planted sorghum, 10 acres of early planted sorghum, and 10 acres of cotton. Two replicates were immediately adjacent to the river, and two were approximately 1,200 ft from the river. Two blocks of the second replicate overlapped with two of the third (fig. 1). The remainder of the ranch was farmed in wheat, cotton, alfalfa, and pecans. The best agronomic practices available were used, and the alfalfa was strip cut in the prescribed manner.

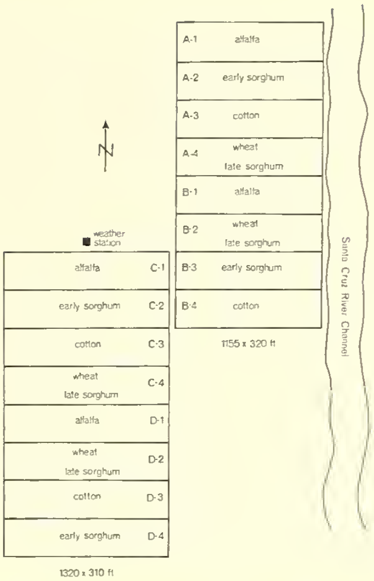

Figure 1.--Plot diagram for Midvale Farms, Tucson, Ariz., 1974.

FIELD METHODS

During the entire growing season, records of the air temperature, relative humidity, evaporation, solar radiation, windspeed and direction, and rainfall were recorded. Irrigation schedules were available from the farm manager.

The planting dates, varieties, and numbers of plants per acre for the row crops are presented in table 1. The planting dates were those commonly employed in the Tucson area, and the varieties were locally recommended. Because the study site in the river valley is a relatively cool area, the planting dates were somewhat later than those in lower portions of the valleys surrounding Tucson. Probably the most critical planting date is that of the sorghum, which, if the system is going to function, must be as early as the weather permits.

TABLE 1.--*Crop data, Midvale Farms, Tucson, Ariz., 1974*

	Planting date	Variety	Plants per acre
Alfalfa	Nov. 10, 1973	819	---
Wheat	Dec. 15, 1974	INIA 66	---
Sorghum:			
Early	Apr. 3, 1974	Anderson Clayton 1090	135,276
Late	June 22, 1974	Pioneer 836	66,061
Cotton	Apr. 11, 1974	Deltapine-16	72,091

The cutting dates for the alfalfa are presented in table 2. The sequence in which half of each 10-acre block was cut at a given date was generally effected with the exception of a single replicate on which the cutting was delayed because of rain. The single replicate block was returned to the regular schedule as rapidly as the growing conditions permitted.

TABLE 2.--*Alfalfa cuts, Midvale Farms, Tucson, Ariz., 1974*

Cut	First half	Second half
1st	Apr. 19	May 4
2d	June 1	June 17
3d	July 1[1]	July 24[1]
4th	Aug. 9[2]	Sept. 9[2]
5th	Oct. 5	Oct. 17
6th	Nov. 5	

[1] First half of blocks B1, C1, D1 cut July 1 and July 24. First half of block A1 cut July 17.

[2] Blocks B1, C1, D1 cut Aug. 9 and Sept. 9. Block A1 cut entirely Aug. 20 (both halves).

Throughout the growing season, weed control consisted of established chemical and hoeing practices. Fertilization was at rates recommended for the Tucson area and for the soil type in the study site. Therefore, except for minor changes, the farming practices common to Tucson were used.

Insect populations were sampled by direct inspection of the plants. In the alfalfa, 0.5-m^2 quadrats were used as the basic sampling unit. Ten of these units were taken in each of the two cuts of alfalfa in each field (table 3). Before the initial block was cut, dividing the field, the entire field was sampled as one unit.

For the wheat insect populations, 0.5-m^2 quadrats were used, and all insects within the quadrat were counted and recorded. The number of units within an overall sampling unit and the number of sampling units checked for the sorghum are presented in table 3.

TABLE 3.--*Number and size of sampling units, Midvale Farms, Tucson, Ariz., 1974*

	Sampling units		
	Number/field	Size	Frequency
Alfalfa	20[1]	0.5 m^2	Weekly
Wheat	10-15	0.5 m^2	Do.
Sorghum:			
Early	10-15	1 m	Do.
	20-40	3-10 plants	Do.
Late	60	1 m	Do.
	30-60	3-10 plants	Do.
Cotton	10-40	1 m	Do.
	40	2-10 plants	Do.
	4	40 bolls	Twice weekly
	1[2]	1,200-ft row	Do.

[1] One half in each cut. [2] Bloom count.

When the sorghum was small, 1-m segments of row comprised the basic sampling units, but as the height of the sorghum increased, the number of plants checked was reduced until, in the mature stage, only three plants per unit were used. Likewise, in the cotton, when the seedlings were small, 1-m segments of row were the basic sampling units. As the cotton grew, 10 plants, then 5, and, finally, 2 plants per sample unit were checked.

For the sampling of the pink bollworm, 1,200 ft of row per replicate were checked twice weekly during the peak blooming period, and the blooms and rosettes were counted. The rosettes were removed to the laboratory and held in 9/16-oz cups to determine the level of parasitism in the generation of pink bollworms in the blooms. When bolls became available, four samples of 40 bolls each of vulnerable bolls were picked twice weekly and held in the insectary in ventilated plastic boxes for 3 weeks or until the pink bollworm population had emerged from the bolls and had pupated or finally emerged as adults (*1*).

From the foregoing data, projections of the total populations in each field and in the entire experiment were developed. Hexalure traps (*1*) were maintained throughout the study area and were checked weekly.

PARASITE REARING METHODS AND FIELD LIBERATIONS

The host and parasite rearing methods used in this study were discussed previously by Bryan et al. (*1*, *2*). The *B. kirkpatricki* were reared on the larvae of the beet armyworm, *Spodoptera exigua* (Hübner); the *C. blackburni* were reared on the eggs and larvae of the pink bollworm. The numbers of the two parasites released are presented in table 4. Early in the season, the *C. blackburni* were introduced in alfalfa fields, where the only insect hosts were present.

As the sorghum grew, and the potential hosts became available, the releases were made in the sorghum by scattering the parasites from the rearing boxes while walking through the field. When the cotton became available, the releases were concentrated in the developing crop. The *B. kirkpatricki*, parasites directed at the first generation pink bollworms in the bloom, were released in the cotton from June 17 until August 12, the period of maximum bloom and major crop set. The *C. blackburni*, egg-larval parasites directed at the pink bollworm eggs throughout the summer, were released in the cotton from June 17 to September 6.

RESULTS AND DISCUSSION

Pest Populations

Pink Bollworms

Table 5 incorporates the data on the populations of the pink bollworm from June through early September. The sex lure trap catches indicate that the early emergence peak occurred about June 17 and that this portion of the population of overwintering pink bollworms initiated a small generation in the blooms. The second flight peak occurred about July 15 and may be attributed to the emergence of the early F_1 generation from the blooms and possibly from additional emergence of the overwintering population (R. E. Fye, unpublished data). The next peak occurred about August 19 and may be attributed to the emergence of the F_2 and the late-emerging F_1 generations. Thus, the overwintering generation probably

TABLE 4.--*Releases of* C. blackburni *and* B. kirkpatricki, *Midvale Farms, Tucson, Ariz., 1974*

	C. blackburni releases, in thousands, in--			*B. kirkpatricki* releases, in thousands, in--		
Week of--	Alfalfa	Sorghum	Cotton	Alfalfa	Sorghum	Cotton
Apr. 22	52.0					
29	59.0					
May 6	96.0					
13	78.0					
20	73.0					
27		27.0				
June 3		39.0				
10	31.0	117.0			8.0	
17		145.5	80.5	6.0	17.0	32.0
24			275.5			97.0
July 1			317.0			250.0
8			238.0			200.0
15			241.5			180.0
22			241.5			204.5
29			290.0			130.0
Aug. 5			391.0			188.0
12			483.5			98.5
19			461.5			
26			568.0			
Sept. 2			483.5			

oviposited both in the blooms and in the early bolls. Once the boll-reared populations were initiated, the number of pink bollworms in the vulnerable bolls (12 to 21 days after bloom) rose rapidly to damaging levels (table 5).

Lygus spp.

Small populations of *Lygus* nymphs were initiated in the alfalfa by undetected, mobile, migrant females in mid-March (Appendix table 1). After this generation matured, the populations rose slowly until mid-June when the overall population stabilized and remained relatively so until after the first week in July. Both nymphs and adults attained stability. The majority of the *Lygus* remained in the alfalfa although small numbers were detected in other crops. The stability may possibly be attributed to the reduction in the numbers of nymphs at the time of each alfalfa cutting (table 2). During July, a major increase in the *Lygus* populations occurred, but the *Lygus* remained in the alfalfa until late July. Although, at this time, some adults shifted to the cotton, reproduction was not evident except during the first and last weeks of August and early September. However, a major population of nymphs developed in the heads of the early sorghum, which were in the early dough stage. At the time this occurred, TABLE 5.--*Pink bollworm infestations*

Week of--	Total pink bollworms in 40-acre cotton		Trap catches
	In blooms	In bolls	
	Number/day	*Thousands*	*Number/trap/week*
June 3			0.08
10			.04
17			6.19
24	0		.89
July 1	0		1.00
8	1,822		.19
15	7,408	271.3	2.14
22	2,333	288.3	.71
29	212	1,243.2	.82
Aug. 5	387	3,310.8	.44
12		5,154.2	4.07
19		5,114.4	7.37
26		3,241.7	6.46
Sept. 4		3,009.4	1.81
12		5,571.6	35.40

the alfalfa heads had been reduced to an unattractive condition by a major influx of the alfalfa caterpillar, *Colias eurytheme* Boisduval.

Other Pests

The data in Appendix table 1 indicate that the bollworm, *H. zea* (Boddie), was of little consequence in the study plots during 1974. Small, sporadic populations occurred in the cotton and sorghum but never reached a damaging level in either crop.

Relatively small populations of the cabbage looper, *Trichoplusia ni* (Hübner), (App. table 1) occurred during 1974, and the populations did not reach the levels common in Arizona in late August. Therefore, the cabbage loopers, which commonly furnish a large volume of potential food for the predator population, failed to develop and may have been partially controlled by the predator population (App. table 1).

Populations of the cotton leafperforator, *Bucculatrix thurberiella* Busck, (table 6) attacked the seedling cotton in early May, continued in light populations during June and July, and, in late August, developed large populations, which were controlled by insecticides in late August on the remainder of the ranch. The large populations of perforators occurred after the predators had decreased in numbers (App. table 1).

Small populations of the greenbug occurred in the wheat early in the season (App. table 1). At the same time that the small populations of the greenbugs occurred in the wheat, relatively large populations of the pea aphid were present in the alfalfa. When the hotter weather in late May and early June caused

TABLE 6.--*Distribution of* Bucculatrix thurberiella *populations*

Week of--	Distribution of populations		
	Mines	Larvae	Pupae
	----------*Population code*[1]----------		
May 6	B		A
13	B		A
20	A		A
27	A		
June 3	A		
10	A		
17		A	
24	A	A	A
July 1		A	
8		A	
15		A	
22		A	
29		A	
Aug. 5	A	A	A
12	A	A	A
19	A	A	A
26	B	B	A
Sept. 2	B	B	B
9	C	C	C

[1] A = very light, B = light, C = medium.

a decrease in the populations of the pea aphid, large populations of Biotype C of the greenbug developed in the early sorghum and remained very large until late July, when the plants began to mature. Small populations of the pea aphid remained in the alfalfa until late August, when Biotype C of the greenbug moved to the late sorghum, but did not increase to large populations. Therefore, from late April until late July, large populations of aphids were available in one or more of the crops to serve as potential food for a developing population of predators.

Bandedwing whitefly populations, *Trialeurodes abutilonea* (Haldeman), (App. table 1) were relatively small and did not contribute to the food supply of the predator populations except in very localized situations.

Black fleahoppers, *Spanogonicus albofasciatus* (Reuter) and *Rhinacloa forticornis* (Reuter), populations were sporadic (App. table 1) but were consistent in selecting cotton and early sorghum as the host crops. Relatively small populations of the nymphs, as compared with the adult populations, indicated that the populations in the test fields were being supplemented by migration from other areas. The continuous shifting of the populations indicates a ready mobility for this group of insects. Irwin et al. (*12*) noted that *S. albofasciatus* is a poor predator of pink bollworm eggs; thus, the role of this plant-feeding predaceous species is probably minor in the natural control of pink bollworms.

Predators

Chrysopa carnea Stephens

The data in Appendix table 1 indicate that *C. carnea* was closely associated with the aphid populations in the sorghum. Very early in the season, adults were detected in the wheat, and some adults and larvae were found in the alfalfa; however, the major populations of both adults and larvae were found in the early sorghum and remained there throughout the summer until the sorghum matured. Some larvae were found in the cotton, however, the percentage figures presented in Appendix table 1 probably overestimate the portion of the population in the cotton because the larvae are extremely difficult to detect in the whorls of the sorghum, where they penetrate deeply to seek out populations of the corn leaf aphid, *Rhopalosiphum maidis* (Fitch). The data strongly suggest that the predator prefers aphids to other less available prey. Therefore, unless aphids can be eliminated from the cropping sequence at some propitious time, the full potential of *C. carnea* as a predator of lepidopterous eggs and larvae will not be realized. Irwin et al. (*12*) considered that *C. carnea* has a potential as a pink bollworm egg predator, and their suggestions will be considered in the final overall discussion.

Collops vittatus (Say)

Although the highly mobile *C. vittatus* adults were found sporadically throughout the cropping system, the majority were associated with the large volume of prey available in the sorghum. However, throughout the major portion of the cotton fruiting period, a relatively large segment was associated with the cotton complex. The size of this segment increased as the season moved into the early maturation period in mid-August (App. table 1). Because the only predation by *Collops* on crop plants is during the adult stage, the mobility enables the predator to move to the available food. R. E. Fye (unpublished data) has noted that the *Collops* are opportunistic in their selection of food and prefer relatively small, immobile prey. Therefore, the effectiveness of this predator against lepidopterous populations would be questionable in light of its disposition to feed on small, immobile prey such as aphids. The breeding ground of the larval population is unknown but is suspected to be in the crop remnants on the surface of the soil in alfalfa and other crops, where many live and dead insects are available.

Hippodamia convergens Guérin-Méneville

H. convergens was closely associated with the aphid populations throughout the season, confirming its disposition as an aphid eater (*19*). The early populations started with the greenbug in the wheat, shifted to pea aphids in the alfalfa, and thence to the Biotype C of the greenbug in the early sorghum (App. table 1). Only when the aphid populations declined in the maturing early sorghum did the *H. convergens* shift to the cotton. However, by that time, the populations had declined to smaller numbers, and the critical fruiting period of the cotton had terminated. Therefore, the value of *H. convergens* as a predator of cotton insect pests is questionable, particularly since the reproduction of this species in cotton is relatively small and, in most seasons, occurs only rarely.

Nabis spp.

Early populations of *Nabis* spp. (App. table 1) developed slowly in the alfalfa and peaked in early July when the common prey, *Lygus* spp., were at their peak. From the alfalfa, the *Nabis* readily spread into the cotton and the sorghum, and, when the *Lygus* reached their peak in the early sorghum, the *Nabis* nymph population was closely associated with the *Lygus*. The relatively higher populations of adults indicate that the adults have a prolonged activity, or a strong migratory capability, or both. Irwin et al. (*12*) found that *Nabis americoferus* Carayon and *Nabis alternatus* Parshley adults were relatively strong predators of pink bollworm eggs. Although the *Nabis* adults occurred consistently in the cotton throughout the season, the numbers were relatively small and were probably a minor mortality factor in regard to pink bollworm eggs.

Sinea spp. and *Zelus* spp.

Populations of *Sinea confusa* Caudell and *Zelus renardii* Kolenati were relatively small (App. table 1), and only scattered individuals were detected by the survey during May, June, and July. During August, the populations increased to a readily detectable level, which, due to the voraciousness of the species, may have had significant impact on pest populations.

Geocoris spp.

Geocoris adults were detected in early March, but the nymphal stages were not detected until mid-May (App. table 1). Although the adult populations were spread over the full crop array, the nymphal stages were found mainly in the alfalfa. Late in the season, however, there was some shift of nymphs to the cotton and sorghum. As with *Nabis*, the number of adults was greater than that of the nymphs, reflecting a substantial longevity and a strong migratory capacity. The sporadic distribution of these predators over the several crops indicates that the predator has a broad range of prey, substantiating laboratory data to this effect (R. E. Fye, unpublished data). Irwin et al. (*12*) found that *Geocoris pallens* Stål and *G. punctipes* (Say) adults and nymphs were relatively poor predators of pink bollworm eggs until high densities of the predator were attained. Because the prey range of *Geocoris* is broad, the populations in the 1974 experiment were apparently not sufficiently large to result in a major mortality of the pink bollworm eggs.

Orius tristicolor (White)

The nymphal population of *O. tristicolor* was generally restricted to alfalfa throughout the late spring and early summer (App. table 1). During August, major nymphal populations shifted to sorghum and cotton, but overall populations declined. The distribution indicates that the nymphs were generally associated with thrips populations in the alfalfa and, later in the season, cotton and sorghum. The adult populations were more sporadic in their distribution and readily shifted to the blossoms and sorghum heads after July 1. The sporadic distribution indicates that adults, which are not strong predators (*13* and R. E. Fye, unpublished data), were more closely associated with the blooms of the alfalfa early in the season and, later, with the cotton blooms and pollinating sorghum heads.

Ants and *Notoxus calcaratus* Horn

Ants occurred only in small numbers on the plants (App. table 1) and, during the major part of the growing season, were only detected in cotton and sorghum. Because disturbance of the nesting sites destroys the vitality of ant colonies, the continual cultivation and irrigation are probably responsible for the small numbers of colonies.

N. calcaratus adults occurred sporadically during the growing season and were generally confined to the cotton and sorghum although they were occasionally found in alfalfa. Generally, the largest numbers occurred in cotton, but, before the blooming period, the larger numbers occurred in sorghum. The sporadic occurrence of the adult beetles indicates a marked mobility. Irwin et al. (*12*) found that *N. calcaratus* was a poor predator of pink bollworm eggs at low population densities, but was fairly effective when 12 *N. calcaratus* per plant were placed in cage studies.

Spiders

The presence of spiders in virtually every sample of every crop taken throughout the season indicates the large array and versatility of this group of predators (App. table 1). The overall populations of all species developed gradually over the season until about mid-July when the populations leveled off and continued at approximately the same level for the remainder of the season. Spiders occurred in the alfalfa throughout the season, and, although the numbers were reduced at the time of each cutting, the populations remained relatively constant until August when crop vitality and available prey generally declined. Populations in cotton were large and relatively constant throughout the season. Because the cotton and sorghum were not disturbed after the final cultivations in mid-July, the populations of both the soil-inhabiting and plant-inhabiting species were able to develop without interference. Overall, the numbers of spiders were the most constant of all the various species of predators on all the crops.

Discussion of Predators

The populations of predators were generally large throughout the growing season after developing from small, early season populations. However, as in past years, the populations of many species of predators collapsed in mid-August (*1*). This collapse occurred in *Chrysopa* adults, *C. vittatus, H. convergens, O. tristicolor*, ants, and *N. calcaratus*. Only populations of *S. confusa* and *Z. renardii* increased. Populations of *Geocoris* spp. and spiders remained at about the same levels as in prior weeks. The decline in populations in mid-August were concurrent with the decline in populations of aphids in the sorghum. At the same time, populations of *Lygus* in the sorghum (App. table 1), cabbage loopers in the cotton (App. table 1), and populations of cotton leafperforators (table 6) increased. Thus, the populations of most predators declined when the lepidopterous food source was improving, suggesting that the increases in numbers and the maintenance of large populations of predators are more dependent upon populations of aphids than upon Lepidoptera.

The impact of naturally occurring predators was slight upon the populations of pink bollworms. Irwin et al. (*12*) have furnished considerable evidence that most predators were ineffective against pink bollworm eggs until predator populations were relatively large. Working with densities of 1, 3, 6, and 12 predators per plant, they determined that large segments of introduced pink bollworm populations were not consumed until populations of predators reached a density of 6 to 12 predators per plant. *C. carnea* was shown to devour about one-third of the introduced pink bollworm eggs at densities of one to three predators per plant. On the basis of the overall performance of *C. carnea*, Irwin et al. (*12*) called for study of the augmentation of *C. carnea* populations for the control of pink bollworms. The data in Appendix table 1 show a normal, marked preference by naturally occurring *C. carnea* adults for aphids in sorghum, but Ridgway and Jones (*14*) indicated that introduced *C. carnea* performed well against *Heliothis* eggs even in the presence of alternative prey. The egg level of 8.5 million *C. carnea* for July 8 (App. table 1) was the largest potential predator population in this study. However, 98 percent of this population was associated with the aphid population in the early sorghum, and only 2 percent, or 153,000, was present in the 40 acres of cotton. Thus, there was a population of 3,800 *Chrysopa* eggs per acre in the cotton, or about one *Chrysopa* egg for every 20 plants, far below the levels necessary for effective feeding on the pink bollworm eggs.

If we assume that the entire 8.5 million eggs could be made available in the cotton, approximately 213,000 *C. carnea* eggs would have been present in each acre, or approximately three eggs per plant. At three eggs per plant, Irwin et al. (*12*) reported that in their cage studies 26 percent of the introduced pink bollworm eggs were eaten. Thus, at best, and with a full concentration of *C. carnea* eggs in the cotton, the augmentation would require doubling of the effective *C. carnea* larvae to reach effective control levels. With ideal conditions, including (1) the potential to concentrate the naturally occurring *C. carnea* in cotton, (2) continued effectiveness of *C. carnea* outside of cages, and (3) possible help of other naturally occurring predators, the ineffectiveness of current methods for the production of large numbers of predators would operate against the effective augmentation of naturally occurring predators for pink bollworm control.

Introduced Parasites

The results from the parasite introductions are presented in figure 2. At the peak of the bloom generation, about 32 percent of the pink bollworms were attacked by *B. kirkpatricki* and 9 percent, by *C. blackburni*. The recovery of *C. blackburni* from the bloom generation, which was not detected in earlier studies, represents the earlier introductions of the parasite in the cotton (table 4). The parasitism by both parasites is probably underestimated for the following reasons: (1) The exposure time of larvae in blooms to *B. kirkpatricki* was limited because yellow, rosetted, or first-day blooms were sampled; and (2) *C. blackburni* does not recognize eggs previously parasitized and will place large numbers of eggs in a single host egg if oviposition sites are not abundant, resulting in the deaths of both host and parasites (C. G. Jackson, unpublished data).

The total parasitism of at least 41 percent, probably more, would not effect control of the pink bollworm, but does represent a substantial portion of the population. This 41 percent is an especially significant portion of a low-density F_1 population in the blooms (that is, about 5 blooms infested per 1,000 or 0.5 percent).

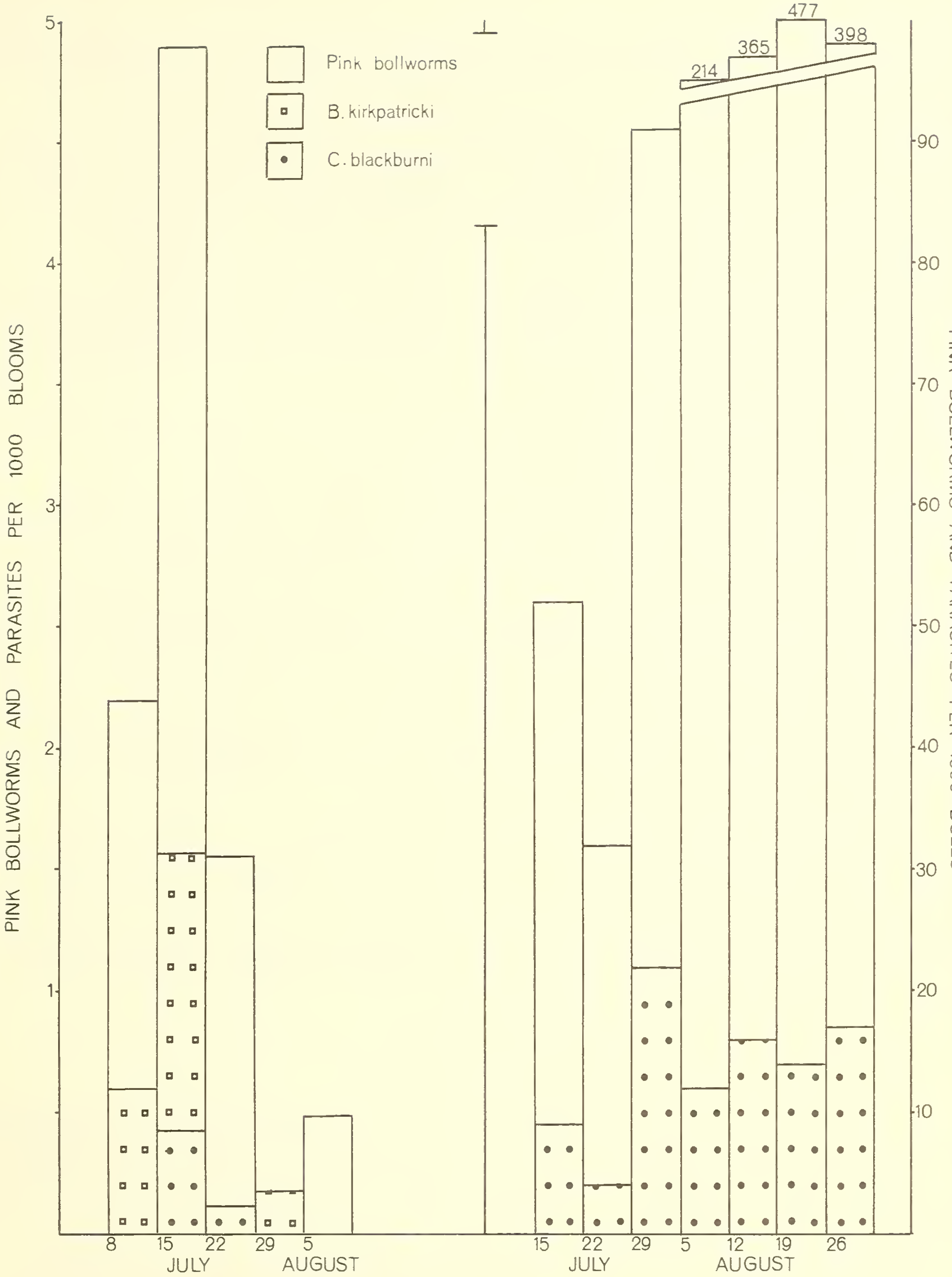

Figure 2.--Results of parasite introductions.

The relatively high parasitism rate demonstrates an effective searching capacity by the parasites, especially *B. kirkpatricki*.

Once bolls were set on the plants and the majority of the pink bollworm eggs were laid on these bolls, the parasitism by *B. kirkpatricki* was reduced considerably. *B. kirkpatricki* emerged from only two samples of larva-infested bolls at a negligible rate of 0.4 and 1.5 percent. Parasitism by *C. blackburni*, however, continued at about the same level. An average of 8.7 percent of the pink bollworms in bolls was parasitized. The percentage parasitized was as high as 17 to 25 percent during late July, but declined to as low as 2 to 4 percent as the pink bollworm population increased later in the season.

For the parasites to be successful, pink bollworm populations must be low and the parasites, highly effective. The cultural controls applied in the vicinity of the study site were inadequate to provide the low initial populations, and the parasites were unable to match the high oviposition potential of the pink bollworms.

Cultural Controls and Population Manipulations

The failure of cultural controls in the vicinity of study sites may be attributed to two factors: (1) Although the grower properly disposed of the 1973 crop residue by shredding and deeply plowing the 1973 cotton land, he did not have sufficient water to irrigate, and the lack of winter rains failed to seal the fallowed cotton land, leaving the overwintering pink bollworms access through the opening between the plowed layers. Thus, the diapausing segment of a small, fall generation was available to initiate populations in the spring of 1974. (2) More critically, the lack of crop sanitation for the 1973 cotton on an adjacent ranch resulted in large, overwintering migration of pink bollworms into the study plots. Because the adjacent ranch raises long-staple cotton, which develops somewhat later than the short-staple cotton raised on the study site, the migrating, overwintering populations moved into the more advanced short-staple cotton.

The use of a long-term sorghum that did not mature at an early date resulted in the predator populations remaining in the sorghum in association with the large populations of Biotype C of the greenbug. Therefore, the predators were not available to feed upon early populations of pink bollworm eggs in the cotton. However, as noted in the discussion above, the effectiveness of most of the predators in the sorghum is limited, and the full shift of the population would have had little effect upon the populations of pink bollworms in the cotton.

CONCLUSION

Due to the lack of large, effective populations of naturally occurring predators and the limited effectiveness of the introduced parasites, pink bollworm populations attained damaging levels in the study sites. The results suggest that the methods proposed, including block cropping to promote beneficial insect populations and introducing *B. kirkpatricki* and *C. blackburni*, are inadequate for the control of pink bollworm unless the populations have been reduced to minimal size by bioclimatic factors, or properly applied cultural controls, or both. The retention of the *Lygus* within the alfalfa was generally successful, and populations of other pest species remained low. Although the methods without proper cultural control were unsuccessful for control of the pink bollworm, further investigations for the control of other target insects should be made before abandoning these concepts of noninsecticidal control.

LITERATURE CITED

(1) Bryan, D. E. Fye, R. E., Jackson, C. G., and Patana, R.
1973. Releases of *Bracon kirkpatricki* (Wilkinson) and *Chelonus blackburni* Cameron for pink bollworm control in Arizona. U.S. Dept. Agr. Prod. Res. Rpt. 150, 22 pp.

(2) _____ Fye, R. E., Jackson, C. G., and Patana, R.
1973. Releases of parasites for suppression of pink bollworms in Arizona. U.S. Dept. Agr., Agr. Res. Serv. ARS W-7, 8 pp.

(3) Burleigh, J. G., Young, J. H., and Morrison, R. D.
1973. Stripcropping's effect on beneficial insects and spiders associated with cotton in Oklahoma. Environmental Ent. 2: 281-285.

(4) Chapman, A. J., Noble, L. W., Robertson, O. T., and Fife, L. C.
1960. Survival of the pink bollworm under various cultural and climatic conditions. U.S. Dept. Agr. Prod. Res. Rpt. 34, 21 pp.

(5) DeLoach, C. J., and Peters, D. G.
1972. Effect of strip-planting vs solid-planting on predators of cotton insects in southeastern Missouri, 1969. Environmental Ent. 1: 94-102.

(6) Fye, R. E.
1971. Grain sorghum--a source of insect predators for insects on cotton. Prog. Agr. in Ariz. 23: 12-13.

(7) _____
1972. Cotton pest and predator reservoirs in Avra Valley. Prog. Agr. in Ariz. 24: 15-16.

(8) _____
1972. The interchange of insect parasites and predators between crops. PANS 18: 143-146.

(9) _____ and Carranza, R. L.
1972. Movement of insect predators from grain sorghum in cotton. Environmental Ent. 1: 790-791.

(10) _____ and McAda, W. C.
1972. Laboratory studies of the development, longevity, and fecundity of six species of lepidopterous pests of cotton in Arizona. U.S. Dept. Agr. Tech. Bul. 1454, 71 pp.

(11) _____
1974. Plant host sequence of major cotton insect predators in southern Arizona. U.S. Dept. Agr., Agr. Res. Serv. ARS W-24, 9 pp.

(12) Irwin, M. E., Gill, R. W., and Gonzalez, D.
1974. Field cage studies of native egg predators of the pink bollworm in southern California cotton. Jour. Econ. Ent. 67: 193-196.

(13) Kuehl, R. O., and Fye, R. E.
1972. An analysis of the sampling distributions of cotton insects in Arizona. Jour. Econ. Ent. 65: 855-860.

(14) Ridgway, R. L., and Jones, S. L.
1968. Field cage releases of *Chrysopa carnea* for suppression of populations of the bollworm and the tobacco budworm on cotton. Jour. Econ. Ent. 61: 892-898.

(15) Robinson, R. R., Young, J. H., and Morrison, R. D.
1972. Stripcropping effects on abundance of predatory and harmful cotton insects in Oklahoma. Environmental Ent. 1: 145-149.

(16) Sevacherian, V., and Stern, V. M.
1974. Host plant preferences of lygus bugs in alfalfa-interplanted cotton fields. Environmental Ent. 3: 761-766.

(17) Stern, V. M., van den Bosch, R., Leigh, T. F., and others.
1967. *Lygus* control by strip cutting alfalfa. Calif. Agr. Ext. Serv. Bul. AXT-241.

(18) Stoner, A.
1972. Insects associated with *Sphaeralcea* spp. in southern Arizona. U.S. Dept. Agr., Agr. Res. Serv. ARS 33-133, 11 pp.

(19) van den Bosch, R., and Hagen, K. S.
1966. Predaceous and parasitic arthropods in California cotton fields. Calif. Agr. Expt. Sta. Bul. 820, 32 pp.

(20) Watson, T. F., and Larsen, W. E.
1968. Effects of winter cultural practices on the pink bollworm in Arizona. Jour. Econ. Ent. 61: 1041-1044.

(21) _____ Barnes, K. K., Slosser, J. E., and Fullerton, D. G.
1973. Influence of plowdown dates and cultural practices on spring moth emergence of the pink bollworm. Jour. Econ. Ent. 67: 207-210.

(22) Wood, Jr., E. A., and Starks, K. J.
1972. Effect of temperature and host plant interactions on the biology of three biotypes of the greenbug. Environmental Ent. 1: 230-234.

APPENDIX

Table 1.--*Distribution of insect predator populations among crops*

	Percent of total predators in--						Percent of total predators in--					
		Alfalfa						Alfalfa				
Week of--	Wheat + late sorghum	Cut 1	Cut 2[1]	Cotton	Early sorghum	Total predators in 160 acres (thousands)	Wheat + late sorghum	Cut 1	Cut 2[1]	Cotton	Early sorghum	Total predators in 160 acres (thousands)
	Lygus spp. nymphs						*Lygus* spp. nymphs					
Mar. 18		100				31.2						
25		100				7.8						
Apr. 1								100				7.8
8		100				15.7		100				15.7
15		100				124.8		100				78.4
22		100				7.8		100				27.3
29		75	25			15.6		50	50			15.6
May 6		47	53			66.3		0	100			7.8
13		31	69			304.2		0	100			31.2
20		40	60			78.5		0	100			94.2
27		53	43	2	2	379.3		45	50	5		164.0
June 3		88	10	2		399.8		84	7	9		281.8
10		73	24	2	1	2,266.7		67	21	2	10	266.2
17		22	78	.1	.1	3,644.2		21	77	2		227.7
24		5	95	.1	.1	3,942.3		16	83	1		249.3
July 1		31	6-62	1		3,801.9		16	11-62	10		287.4
8		21	10-69	.4		6,606.3		38	18-41	2		508.2
15		53	15-32			14,749.8		26	6-60	6	1	2,106.4
22		59	36- 1	3	1	8,858.8		43	26- 2	23	6	742.7
29	1	2	86- 2	8	.5	7,016.9	2	2	30- 1	53	11	1,152.7
Aug. 5	1	1	65- 1	24	7	2,137.9	2	2	18- 3	52	22	1,357.6
12	.4	5	0.1- 9	3	83	20,608.5	3	3	0.3-0.3	21	73	3,795.4
19				6	94	11,598.0	<1	3	4	9	84	4,344.1
26	.6	3		13	84	1,127.0	19	12	8	4	57	2,068.5
Sept. 2		7		4	90	335.1	19	38	23	20		352.2
9	20				80	74.7	41	22	17	19		248.4
	H. zea eggs						*H. zea* first to third instar larvae					
May 27											100	20.4
July 8										100		9.0

See footnotes at end of table.

Table 1.--*Distribution of insect predator populations among crops*--Continued

Week of--	Percent of total predators in--					Total predators in 160 acres (thousands)	Percent of total predators in--					Total predators in 160 acres (thousands)
	Wheat + late sorghum	Alfalfa		Cotton	Early sorghum		Wheat + late sorghum	Alfalfa		Cotton	Early sorghum	
		Cut 1	Cut 2[1]					Cut 1	Cut 2[1]			
	H. zea eggs--Continued						*H. zea* first to third instar larvae--Continued					
July 29							38		5	43	14	82.0
Aug. 5				100		18.0	15			60	25	44.9
12										100		27.0
19				100		72.0						
26												0
										100		36.0
Sept. 2										100		12.0
	H. zea fourth instar larvae						*H. zea* larvae > than fourth instar					
July 1	100					6.8						
22				100		9.0				100		9.0
Aug. 5	37				63	17.9				100		9.0
12				100		9.0						
26						0						0
Sept. 2	48	13		39		30.6						0
9						0				100		12
	Trichoplusia ni eggs						*Trichoplusia ni* larvae					
Apr. 1								100				7.8
May 6				100		8.0				100		4.0
13				100		5.4				100		10.8
20				100		2.0				100		12.0
27												0
June 3												0
10								49		51		7.9
17												0
24									100			3.9
July 1												0
8								23	23	54		16.8
15										100		18.0
22										100		9.0
29												0
Aug. 5										100		108.0

Aug.	12									100		126.0
	19				100		180.0			100		144.0
	26						0			100		24.0
Sept.	2				100		96.0			100		84.0
	9						0		10	90		39.9
				Aphids[2]					Whiteflies[3]			
Feb.	11	(4)										
Mar.	4		(4)									
	11		(4)									
	18	(4)	(4)									
	25	(4)	(4)									
Apr.	1	(4)	(5)									
	8	(4)	(4)						(4)			
	15	(4)	(5)									
	22	(4)	(6)	(4)								
	29	(4)	(6)	(4)		(6)					(4)	
May	6	(4)	(4)	(5)		(6)				(4)	(4)	
	13		(4)	(5)		(6)				(4)	(4)	
	20		(4)	(4)		(6)				(4)		
	27		(4)	(4)	(4)	(5)				(4)		
June	3		(5)	(4)	(4)	(5)				(4)	(4)	
	10		(5)	(4)		(5)				(4)	(4)	
	17		(4)	(7)	(4)	(7)				(4)		
	24		(4)	(5)	(4)	(6)				(4)		
July	1		(4)	(8)		(7)						
	8		(4)	(9)		(7)						
	15		(5)	(8)		(7)						
	22	(5)	(5)	(10)		(7)						
	29	(4)	(4)	(10)		(4)						
Aug.	5	(4)	(4)	(10)	(4)	(4)				(4)	(4)	
	12		(5)	(8)	(4)	(4)				(4)		
	19	(5)	0	0	(4)	(4)					(4)	
	26	(5)	0	0	0	(4)						
Sept.	2	(5)	(4)	(4)	0							
	9	(5)	(4)	0	0							
			Black fleahoppers nymphs[11]						Black fleahoppers adults[11]			
May	20		100				15.7			75	25	10.7
	27			89	11		17.6	9		5	86	126.5
June	3			13	49	39	30.9	29		15	56	234.3
	10		11	11	57	20	34.8	23	7	36	35	175.8
	17		6		88	5	124.4	3	6	44	46	248.8
	24		8		75	18	101.4	1	15	54	30	333.6
July	1						54.0		-16	45	39	121.1

See footnotes at end of table.

Table 1.--*Distribution of insect predator populations among crops*--Continued

	Percent of total predators in--					Total predators in 160 acres (thousands)	Percent of total predators in--					Total predators in 160 acres (thousands)
		Alfalfa						Alfalfa				
Week of--	Wheat + late sorghum	Cut 1	Cut 2[1]	Cotton	Early sorghum		Wheat + late sorghum	Cut 1	Cut 2[1]	Cotton	Early sorghum	
	Black fleahoppers nymphs[11]--Continued						Black fleahoppers adults[11]--Continued					
July 8		32		27	40	362.9		24		29	47	499.4
15		7		60	32	104.7		10		17	73	311.2
22	10			90		100.5	12	1		29	58	407.2
29	31	18	9	42		42.9	63	1	.6	10	24	604.4
Aug. 5	9		3	28	60	284.7	40			13	47	411.1
12	11			12	77	450.7	32			21	46	338.8
19	7			8	85	425.2	31		1	8	59	302.8
26	50				50	29.6	63				37	81.1
Sept. 2	100					7.3		100				29.2
9		100				3.9	79	21				18.6
	Chrysopa carnea eggs						*Chrysopa carnea* larvae					
Apr. 22								100				3.9
29								100				3.9
May 6								81			19	14.4
13					100	51.3						
20				3	97	133.6						
27				10	90	308.8			78		22	17.5
June 3				22	78	323.0				1	99	632.0
10		1		7	92	785.5				100		7.0
17				2	98	3,045.0		4	20		76	196.4
24				3	97	2,566.8					100	54.0
July 1				3	97	3,292.8		11		16	73	74.2
8				2	98	8,515.8				21	79	128.7
15				4	96	3,179.3				58	42	108.2
22				5	95	4,665.9		6		4	90	250.6
29	1			17	82	702.1		3		15	82	123.6
Aug. 5	1			8	91	670.8				100		27.0
12	5			39	56	761.1				10	90	174.8
19	54			26	20	1,438.1	9			24	67	246.9
26	44			11	45	3,063.9	6			20	74	121.3
Sept. 2	44			56		1,895.5	49			51		118.4
9	75					2,352.0	80	4		16		220.2

Chrysopa carnea adults

Mar.	11		100				63.0
	18	100					15.7
	25	25	75				31.3
Apr.	1		100				46.8
	8		100				62.8
	15		100				7.8
	22		100				11.7
May	6		81			19	14.4
	13		4	52		44	179.7
	20		17			83	182.6
	27			15	6	79	155.8
June	3		15	4	5	76	314.0
	10		11	1	1	88	624.9
	17		1	1	3	95	1,629.8
	24		1		6	93	743.7
July	1				6	94	3,044.4
	8		.2	.2	6	94	8,364.9
	15				5	95	5,971.9
	22	.1	.1	0.05-0.05	8	92	7,539.1
	29	1			18	80	7,546.1
Aug.	5	14			22	63	5,323.1
	12	18			34	47	4,943.8
	19	33	.2	.2	32	35	1,558.1
	26	38	.2	.5	12	49	2,176.8
Sept.	2	49	.7	.3	50		1,065.3
	9	80			20		1,561.5

Collops vittatus adults

Apr.	22		100				11.7
	29	21				79	25.2
May	6		50	50			7.8
	13	19				81	14.4
	27				100		8.0
June	3				4	96	25.0
	10		23	6	1	70	68.1
	17				1	99	377.6
	24		1	15	11	73	295.2
July	1		4	2- 4	23	66	819.7
	8		3	2- 1	6	88	2,541.3
	15		7	8- 2	19	65	1,973.7
	22	3	1	0.4-0.4	17	78	3,196.2
	29	18	.2	2-0.2	18	61	2,320.7
Aug.	5	14	1	3-0.3	29	53	1,151.1

See footnotes at end of table.

Table 1.--*Distribution of insect predator populations among crops*--Continued

Week of--	Percent of total predators in--					Total predators in 160 acres (thousands)	Percent of total predators in--					Total predators in 160 acres (thousands)
	Wheat + late sorghum	Alfalfa		Cotton	Early sorghum		Wheat + late sorghum	Alfalfa		Cotton	Early sorghum	
		Cut 1	Cut 2[1]					Cut 1	Cut 2[1]			
	Collops vittatus adults--Continued											
Aug. 12	17	1	0.6- 1	45	35	889.3						
19	31	10	8	31	20	305.5						
26	57	5	10	8	20	153.0						
Sept. 2	27	24	34	15		80.7						
9	36	6		58		123.9						
	Hippodamia convergens eggs						*Hippodamia convergens* larvae					
Mar. 11								100				10.5
18	100					85.8						
25								100				15.6
Apr. 1		100				93.6		100				7.8
8								100				204.1
15	100					270.4	5	95				296.4
22	100					471.0	55	45				227.0
29		24			76	337.9		69	5		25	141.3
May 6							27	15	20		38	77.8
13								8	81		11	48.5
20												0
27									100			15.6
June 3					100	84.0		2	5	.4	93	232.6
10					100	95.2			8	27	66	51.9
17				2	98	2,594.4			1	.2	98	795.5
24					100	9.0				.4	100	6,361.2
July 1					100	510.0					100	1,183.2
8					100	7,808.3		1			99	1,258.6
15					100	4,282.7				.1	100	6,495.2
22					100	2,090.5	1	1			98	1,806.1
29	64		4		33	103.8	50				50	316.6
Aug. 5	80				20	57.5					100	372.9
12						0		30		70		12.9
19						0				100		24.0
26						0	91	9				88.1
Sept. 2						0		100				19.5
9			100			3.9	100					88.2

		Nabis spp. nymphs						*Nabis* spp. adults					
Apr.	1								100				7.8
	15		100				39.0						
	29		100				3.9		67	33			11.7
May	6									59		41	6.6
	13			100			3.9		20	80			19.5
	20				100		2.0						
	27		42	53	5		37.1		11	37	5	47	146.2
June	3		27	20	53		39.3		79	7	14		231.6
	10		20	49	13	18	192.6		57	13	16	13	413.9
	17		15	65	8	12	232.4		17	51	25	7	503.2
	24		22	61	9	7	382.8		12	58	23	7	413.0
July	1		52	22- 7	6	13	105.4		29	2-31	31	7	748.6
	8		55	35- 5	5		565.2		50	19- 9	13	10	917.2
	15		28	40-19	6	7	321.4		35	29-19	12	6	778.7
	22	3	34	44-15	4		425.9	2	40	35- 0	16	6	421.2
	29	22	6	32- 3	16	20	276.2	18	2	40-19	18	3	407.7
Aug.	5	15	7	20-11	21	26	390.3	8	8	46-14	21	2	545.0
	12	3	32	-19	13	33	205.2	7	33	9-13	29	10	466.3
	19				41	59	204.0	18	2	2	59	18	163.0
	26	44	11			45	33.5		15			85	52.8
Sept.	2		100				15.6	17	64	18			42.4
	9		100				3.9		100				15.6
		S. confusa Caudell and *Z. renardii* Kolenati nymphs						*S. confusa* Caudell and *Z. renardii* Kolenati adults					
Mar.	11								100				10.5
May	13									100			15.6
June	3				100		2.0		100				5.3
	10				100		1.0						
	17										100		1.8
	24					100	18.0					100	9.0
July	1			0-100			7.8						
	8									0-100			7.8
	29					100	11.3						
Aug.	5				100		27.0			41-0		59	19.1
	12			18	82		21.9			100			3.9
Aug.	19	33				66	22.3	21	23	11		44	34.0
	26			100			3.9		21			79	18.9
Sept.	2		66		34		35.4		100				3.9
	9				100		12.0		19	19	61		19.8
		Geocoris spp. nymphs						*Geocoris* spp. adults					
Mar.	11								100				10.5
	18								100				7.8

See footnotes at end of table.

Table 1.--*Distribution of insect predator populations among crops*--Continued

Week of--		Percent of total predators in--					Total predators in 160 acres (thousands)	Percent of total predators in--					Total predators in 160 acres (thousands)
		Wheat + late sorghum	Alfalfa		Cotton	Early sorghum		Wheat + late sorghum	Alfalfa		Cotton	Early sorghum	
			Cut 1	Cut 2[1]					Cut 1	Cut 2[1]			
		Geocoris spp. nymphs--Continued						*Geocoris* spp. adults--Continued					
Mar.	25								100				7.8
Apr.	1								100				46.8
	8								100				15.7
	15								100				31.2
	29								50	50			7.8
May	6								67	33			11.7
	13								23	77			50.9
	20				100		6.0			68	32		69.1
	27		9	26	66		45.6		20	12	55	14	98.8
June	3		21	47	32		25.0		70	3	27		112.7
	10		30	9	30	30	89.3		33	25	14	29	236.5
	17		33	53	3	11	59.3		5	12	61	21	221.6
	24		40	60			19.5		17	29	2	53	205.2
July	1		3	55- 0	30	11	119.8		0	13- 6	62	19	211.8
	8		33	0-67			23.4		11	0- 0	26	62	651.9
	15								6	0- 0	11	83	296.1
	22		42	53- 0	5	0	545.7		4	9- 0	13	73	808.3
	29	38	6	31- 0	7	18	126.8	15		12- 0	45	28	321.8
Aug.	5	4	1	54-15	27	0	373.5	12	5	14- 3	40	26	430.4
	12	4	4	61- 2	12	17	812.4	4	27	-14	28	27	288.0
	19		.7	.7	31	68	550.8	4	6	4	37	50	392.6
	26	4	6	24	33	33	181.9	20	19	35	4	21	286.4
Sept.	2		58	3	39		153.6	20	38	26	16		297.5
	9	13	23	28	36		234.3	63	4	6	27		351.6
		Orius tristicolor nymphs						*Orius tristicolor* adults					
Mar.	25								100				15.6
Apr.	1								100				93.6
	8								100				47.1
	15								100				124.8
	22								100				46.8
	29		78	22			235.5		62	38			152.1
May	6		73	27			315.9		11	87	2		370.9
	13		45	55			206.7		32	68			378.3

May	20			99	1		237.5		82	18			172.7
	27			47	2	5	273.1		63	23	1	12	664.8
June	3		48	42	6	5	1,192.2		63	5	3	28	1,856.7
	10		83	11	4	1	3,009.1		49	42	5	4	2,788.5
	17		60	37	3		2,418.0		8	67	12	13	2,726.9
	24		24	75	1		1,301.7		27	35	30	7	968.1
July	1		29	14-48	8	1	1,506.4		27	1-38	27	7	922.4
	8		19	7-73	2		2,732.1		27	17-23	21	12	1,494.0
	15		46	34-19	1		2,320.2		29	22-22	18	9	1,585.4
	22		63	23- 3	11		997.2	7	20	16-	39	18	976.1
	29	2	20	54- 3	21		253.4	23	4	7- 4	59	3	330.9
Aug.	5	3		5- 3	67	22	253.6	4	5	2- 5	78	7	499.2
	12	2	3		26	69	716.2	8	13	-7	53	19	594.1
	19				98	2	675.0				95	5	303.0
	26	80			9	11	136.5	91	1	0		8	545.3
Sept.	2	100					547.5	75	1	1	23		667.5
	9	94			6		812.4	90	5	1	4		1,391.4
				Ant adults					*N. calcaratus* adults				
May	13					100	16.2						
	20					100	2.7				100		4.0
	27				8	92	51.6				6	94	310.4
June	3				8	92	13.0				19	81	519.0
	10				100		10.0				72	28	96.2
	17				100		64.8				94	6	565.0
	24				93	7	145.8				96	4	446.4
July	1				1,000		12.0				96	4	524.4
	8								11	4	71	14	415.9
	15								9	16	55	20	442.8
	22				16	83	54.2	21			64	15	954.9
	29	39	17		20	25	45.7	34			55	11	196.6
Aug.	5	26			52	22	51.5	21	3		62	14	158.5
	12					100	100.8	41			36	23	148.1
	19							18			82		161.2
	26		25	25		49	30.6				100		732.0
Sept.	2		66	33			11.7	100	1				7.3
	9	26	74				57.6	88			12		501.0
				Spiders									
Feb.	11	100					7.8						
	18	100					15.7						
Mar.	4	100					7.8						
	11		100				73.5						
	18	50	50				46.9						
	25		100				7.8						

See footnotes at end of table.

Table 1.--*Distribution of insect predator populations among crops*--Continued

	Percent of total predators in--						Percent of total predators in--					
	Wheat + late	Alfalfa				Total predators in 160 acres	Wheat + late	Alfalfa				Total predators in 160 acres
Week of--	sorghum	Cut 1	Cut 2[1]	Cotton	Early sorghum	(thousands)	sorghum	Cut 1	Cut 2[1]	Cotton	Early sorghum	(thousands)
		Spiders--Continued										
Apr. 1		100				7.8						
8		100				78.5						
Apr. 15		100				109.2						
22		88	12			31.2						
29		88	12			66.3						
May 6		15	30	54		51.4						
13		4	72	24		91.8						
20		21	21	35	22	73.6						
27		24	27	25	24	278.4						
June 3		43	18	13	26	279.5						
10		47	23	11	18	333.2						
17		4	35	20	40	487.3						
24		9	26	29	36	671.4						
July 1		10	14-24	29	23	647.6						
8		22	17- 8	16	37	1,423.4						
15		22	7-31	10	30	947.0						
22		16	18-0.3	26	40	1,018.8						
29	5	4	8-0.3	18	65	1,169.6						
Aug. 5	6	0.2	10- 3	23	58	1,378.6						
12	9	7	0.6- 3	19	62	1,412.8						
19	12	4	11	20	53	1,184.2						
26	17	4	7	21	51	2,225.6						
Sept. 2	44	24	14	18		1,345.6						
9	77	8	6	10		2,736.6						

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[1] Second figure in column applies to off-schedule cut (see table 2).

[2] Wheat - *Schizaphis graminum*, Alfalfa - *Acyrthosiphon pisum*, Sorghum - Biotype C of *S. graminum*, Cotton - *Aphis gossypii* Glover.

[3] *Trialeurodes* sp.

[4] Very light.

[5] Light.

[6] Medium.

[7] Heavy infestation.

[8] Contains a second cut (very light infestation) and an off-schedule cut (light infestation).

[9] Contains a second cut and an off-schedule cut (both very light infestations).

[10] Contains a second cut (light infestation) and an off-schedule cut (very light infestation).

[11] *Spanogonicus albofasciatus* (Reuter) and *Rhinacloa forticornis* (Reuter).

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